(4)

Attorney Docket: 3036/49955
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: SIMON PAUL DAVIS ET AL.

Serial No.: 09/864,870 Group Art Unit:

Filed: MAY 25, 2001 Examiner:

Title: IMPROVEMENTS IN OR RELATING TO PACKET SWITCHES

CLAIM FOR PRIORITY UNDER 35 U.S.C. §119

Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of prior foreign application Numbers 0012611 and 0024463, filed in Great Britain on, May 25, 2000 and October 6, 2000 respectively are hereby requested and the right of priority under 35 U.S.C. §119 is hereby claimed.

In support of this claim, filed herewith is a certified copy of the original foreign application.

Respectfully submitted,

Gary R. Edwards
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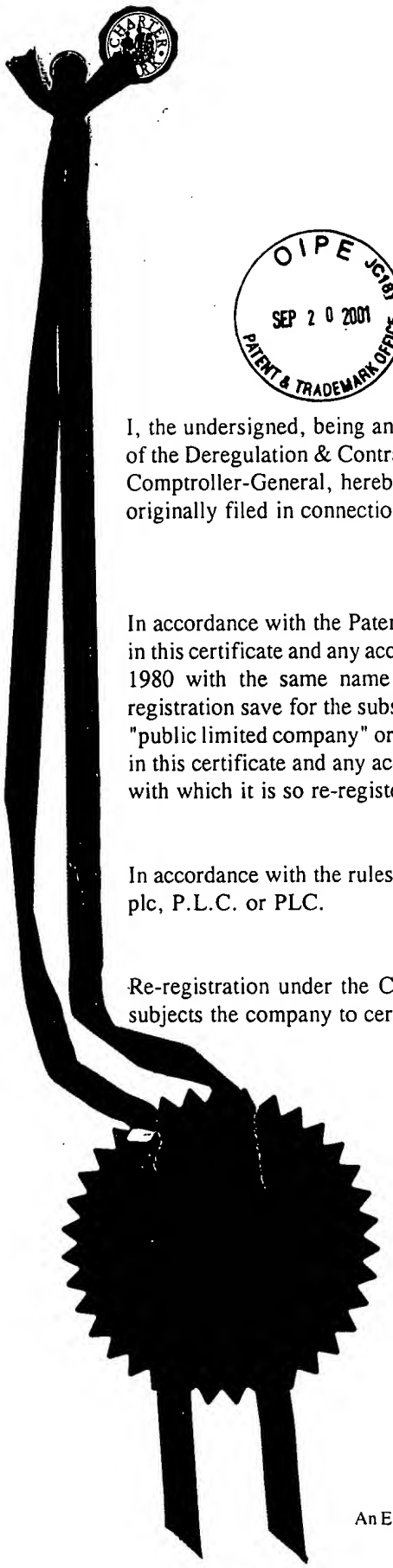

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INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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CERTIFIED COPY OF PRIORITY DOCUMENT

Signed J.E. Evans.

Dated 21 May 2001

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Patents Form 1/77

Patents Act 1977
(Rule 16)

The Patent Office

25MAY00 E539639-1 D00393
P01/7700 0.00-0012611.0

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

2000P04863/GB/R76/MM/rh

2. Patent application number
(The Patent Office will fill in this part)

0012611.0 **25 MAY 2000**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Roke Manor Research Limited
Roke Manor
Old Salisbury Lane
Romsey
Hants SO51 0ZN

Patents ADP number *(if you know it)*

561545500 6

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

IMPROVEMENTS IN OR RELATING TO CROSSBAR SWITCHES

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Siemens Shared Services Limited
Intellectual Property Department
Siemens House, Oldbury
Bracknell, Berkshire RG12 8FZ
United Kingdom

Patents ADP number *(if you know it)*

77610000 02

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	-
Description	4
Claim *(s)*	-
Abstract	-
Drawing *(s)*	2

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature M D Mackett Date 24/05/00

Margaret Mackett

12. Name and daytime telephone number of person to contact in the United Kingdom: Margaret Mackett - 01344 396808

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

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f) *For details of the fee and ways to pay please contact the Patent Office.*

IMPROVEMENTS IN OR RELATING TO CROSSBAR SWITCHES

The present invention relates to improvements in or relating to crossbar switches, and is more particularly concerned with a cell-level scheduling scheme for handling multicast traffic in such switches.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 illustrates multicast ingress rate resolution; and

Figure 2 illustrates multicast scheduling.

The requirements for a multicast scheme in accordance with the present invention are listed below:

- High efficiency (aim for 70-80% pure multicast traffic or better)
- Use shared optical fibre backplane for replication
- Easily integrated into the Unicast cell level scheduling algorithm
- Fair across ingress ports to each egress port
- Supports real time and non real time multicast services
- Maintains unicast bandwidth commitments

It is assumed that there is one multicast IP packet (or fixed length part of such a packet) available to be sent at each ingress LIC.

The fanout of a multicast packet is defined to be the set of egress ports (of the cross connect) to which the packet must be replicated. The fanout of the next multicast cell must be known by the central scheduler in order that it can be scheduled across the cross connect.

It is assumed that the fanout information for the next multicast cell to be sent from each ingress port is known.

Once ingress bandwidths have been allocated for multicast traffic, scheduling opportunities must be allocated for all ingress LICs to ensure fair access and to preserve allocated rates. The basic scheduling concept for multicast slots is shown in Figure 1. Each ingress (labelled 0 to 3 on the left of the Figure) has a rate associated with multicast traffic (high and low priority queues). This is represented as a send opportunity every fixed number of cell periods. The highest rate is that of ingress 1.

These send opportunities are combined into a multicast schedule. The result is shown at the bottom of Figure 1. The algorithm for combining the opportunities is to place the send opportunity on the next free cell cycle (cell cycles are numbered 1 to 16 as shown) unless it would overlap with the next send opportunity for the same ingress LIC. This can be seen on cell period 12 where the send opportunity for ingress LIC 1 has to be stacked on top of the cell send opportunity for ingress LIC 0 to avoid it colliding with its next send opportunity.

The net effect of this process is to spread the multicast send opportunities on as many cell periods as possible thus reducing the height of each stack. The height of each stack is directly related to the number of ingress multicast cells that have to be scheduled in this cycle and thus the amount of sorting that has to be carried out by the algorithm. Whilst minimising the amount of work to be carried out in each cell cycle by the multicast scheduler, the maximum jitter is also limited to 1/rate. A cell send opportunity is never delay by more than the gap between the ideal ingress cell send opportunities, thus making the jitter inversely proportional to the rate. Multicast real time delay jitter can thus be improved by allocating higher rates.

If there is no multicast cell send opportunity scheduled, then the normal unicast scheduling algorithm is invoked. If there is one or more multicast cell send opportunities then the multicast scheduling algorithm is invoked.

Figure 2 shows the active components in the multicast scheduling algorithm. On the left hand side is an ordered list of pointers relating to the stack of multicast send opportunities on this particular cell period. In the example of Figure 2, ingress 1 has first priority to send a multicast cell followed by ingress 6.

The second component of the algorithm is the multicast cell fanout table which contains the current fanout requirements for the cell at the head of the multicast queue in each ingress LIC. As the algorithm supports the concept of scheduling part of the fanout and leaving residues, the entries in this table will change (1s go to 0s when they have been scheduled) when part of the fanout has been scheduled. Another table is thus required to remember the full fanout for the duration of the packet. This second table, called the multicast packet fanout table, is updated when the next fanout is sent to the traffic management card at the end of the packet.

The algorithm starts with a blank schedule and fills this with the full fanout of the 1st choice ingress LIC, as shown on the right of Figure 2 in the compilation of the control frame. It then moves to the next ingress LIC of choice (2nd choice is ingress LIC 6) and schedules as much of the fanout as possible (in this case egress LICs 5 and 6).

For the multicast cells that are scheduled for this cell period (those from ingress LIC 1 and 6 in this example), the eligible bits are set. These bits are only reset when the cell has been scheduled for the complete fanout. The algorithm will then attempt to schedule as many of the other multicast cells

as possible, starting with the one whose ingress LIC number is one larger than the first choice, subject to two constraints. The first is that the eligible bit is set, the second is that the multicast egress credit is positive for a particular egress destination.

The multicast egress credit is decremented each time a multicast cell is scheduled for that particular egress. In a real implementation there will probably be separate credit for real time multicast cells and for non real time multicast cells. This credit can be refreshed by the equivalent allocated egress rates every BAP period or on a sub-multiple of a BAP period depending on the amount of egress smoothing desired.

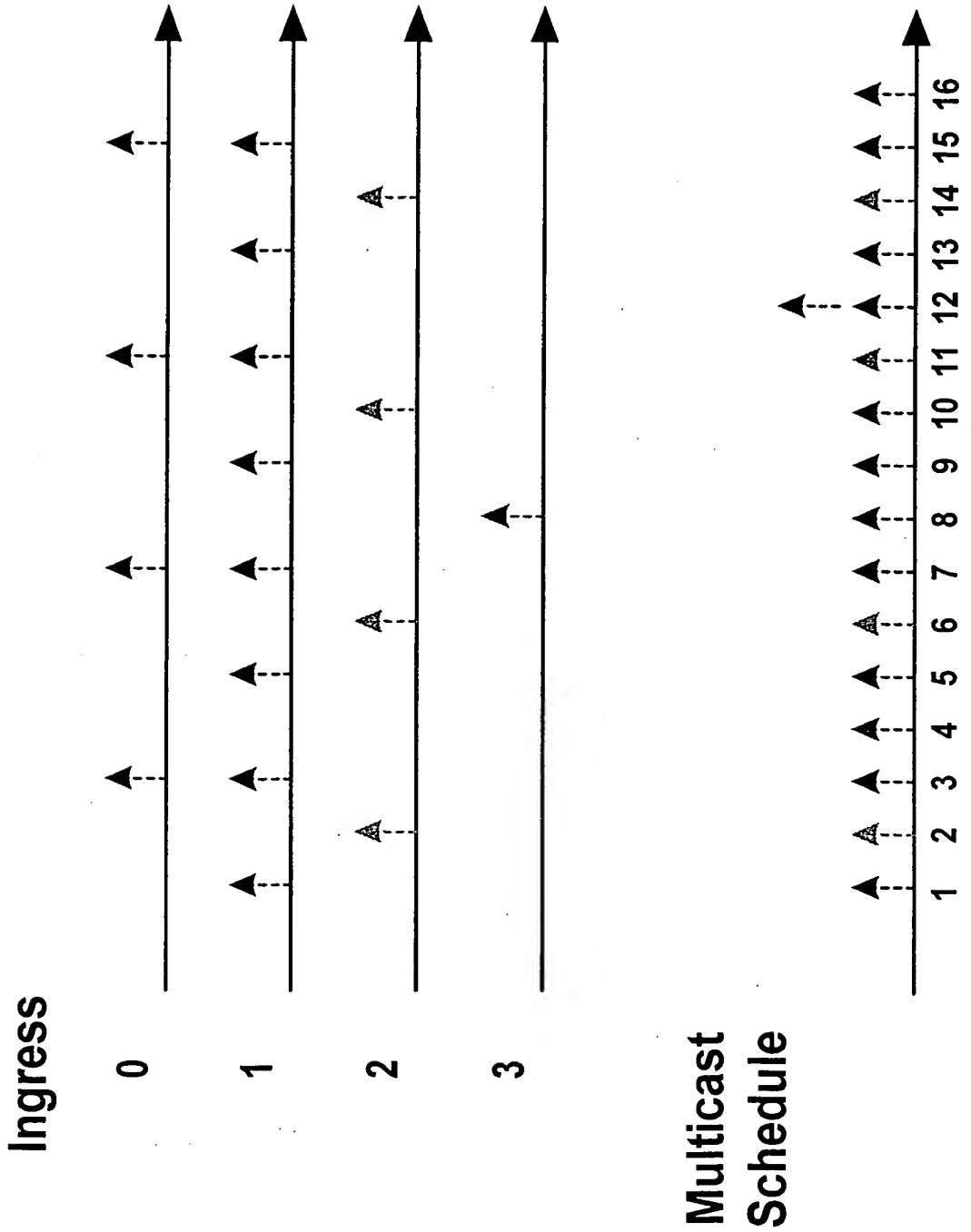
Ingress
0
1
2
3
Multicast
Schedule
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Fig. 1

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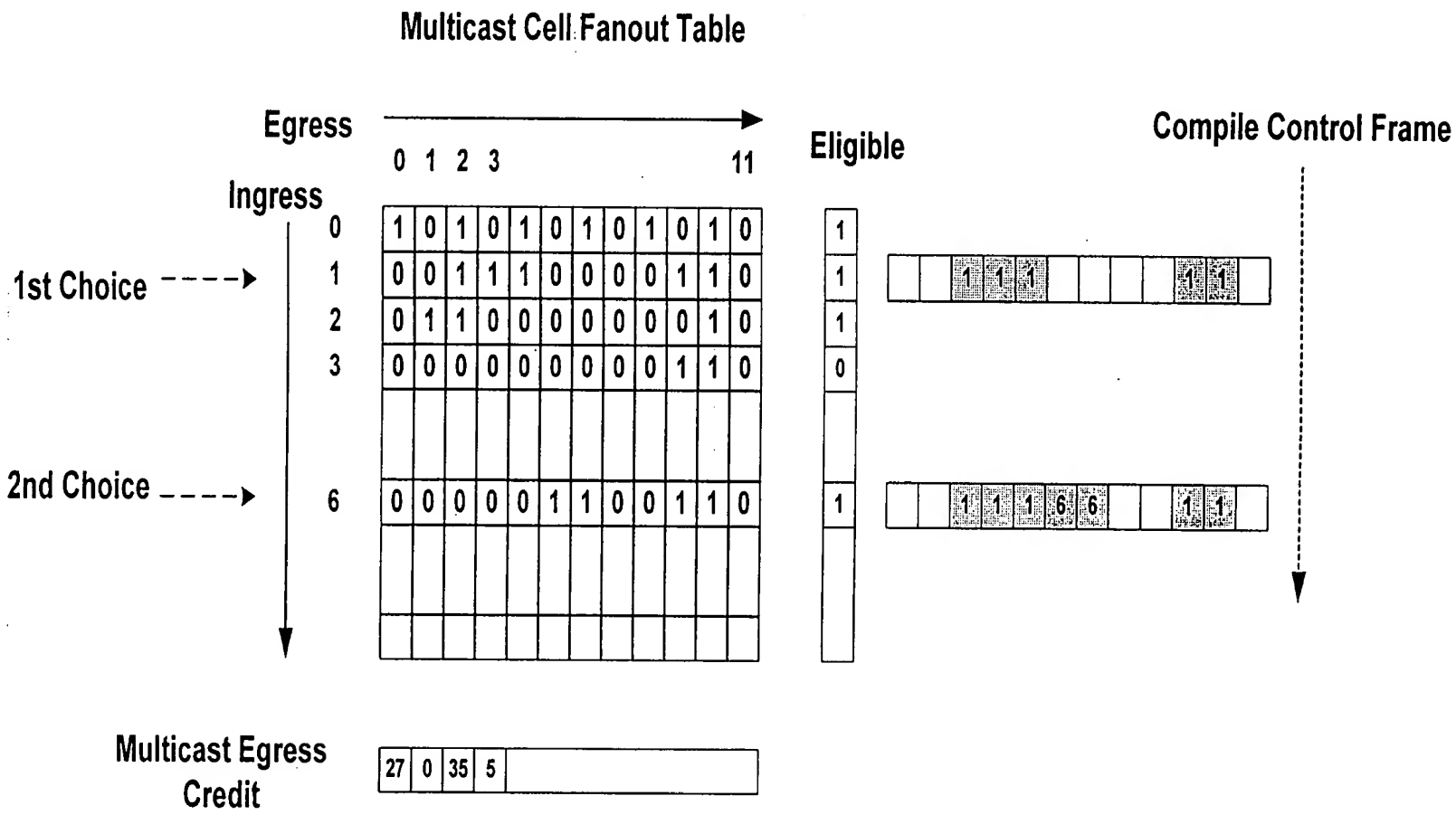
Multicast Cell Fanout Table
Egress
0 1 2 3
11
Ingress
Eligible
Compile Control Frame
1st Choice
2nd Choice
0 1 0 1 0 1 0 1 0 1 0 1
1 0 0 1 1 1 0 0 0 0 1 1 0
2 0 1 1 0 0 0 0 0 0 0 1 0
3 0 0 0 0 0 0 0 0 0 1 1 0
6 0 0 0 0 0 1 1 0 0 1 1 0
1
1
1
0
1
1 1 1 1 1
1 1 1 6 6 1 1
Multicast Egress Credit
27 0 35 5

Fig. 2

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